

Privacy-Preserving Edge-Assisted Video Streaming

PRIVATUBE

S. Da Silva, S. Ben Mokhtar, S. Contiu, D. Négru, L. Réveillère, É. Rivière

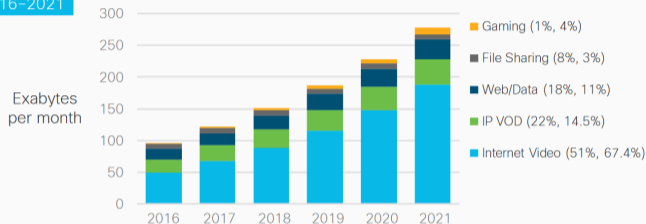


Thursday 12 December 2019

Video content consumption evolves...



24% CAGR
2016-2021



- ▶ High QoE
- ▶ Reliability
- ▶ Low cost

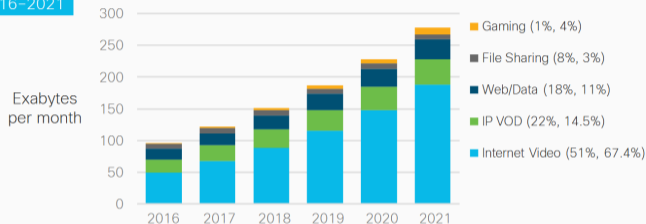
scalability cost

High QoE



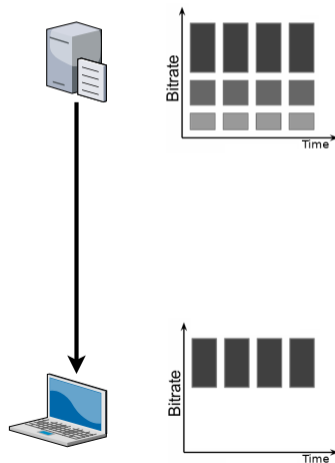
NETFLIX
You Tube
twitch

24% CAGR
2016-2021

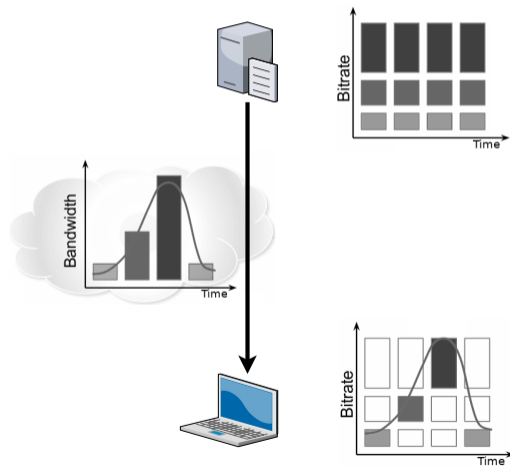


- ▶ High QoE
- ▶ Reliability
- ▶ Low scalability cost

High QoE: HTTP Adaptive Streaming - DASH



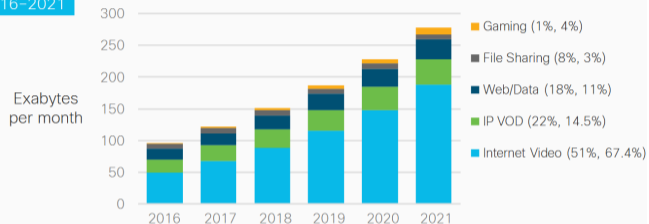
High QoE: HTTP Adaptive Streaming - DASH



Reliability

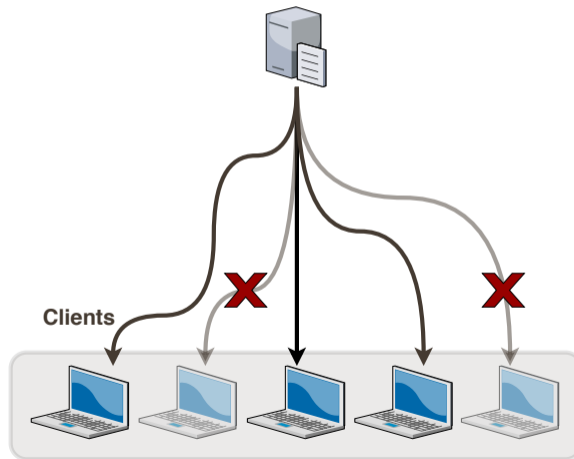


24% CAGR
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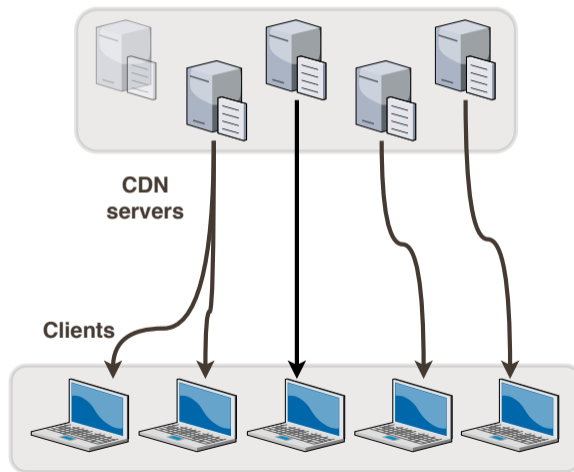


- ▶ High QoE
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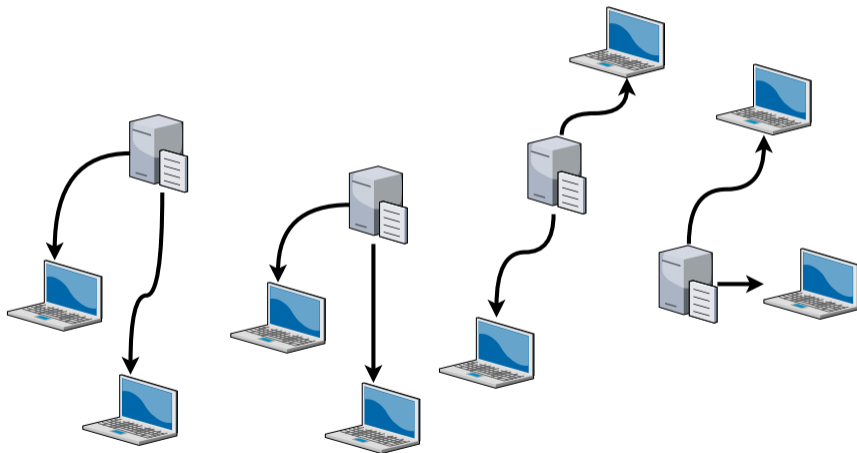
Reliability: Content Delivery Networks (CDN)



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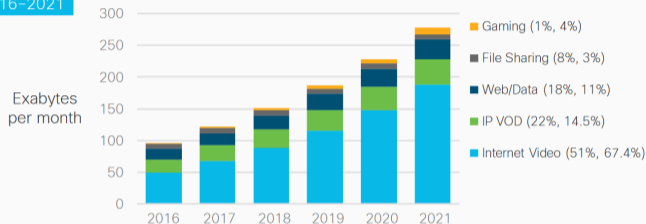
Reliability: Content Delivery Networks (CDN)



Low scalability cost

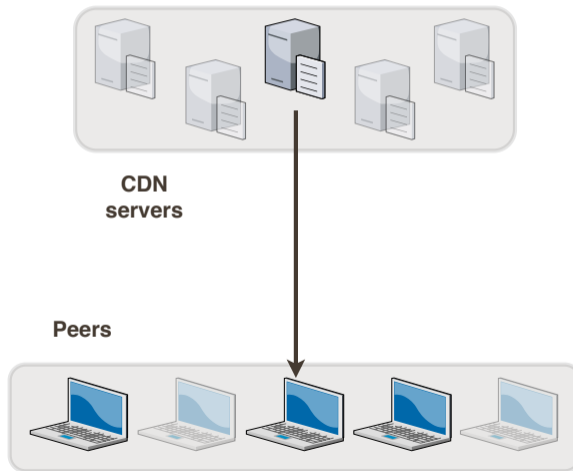


24% CAGR
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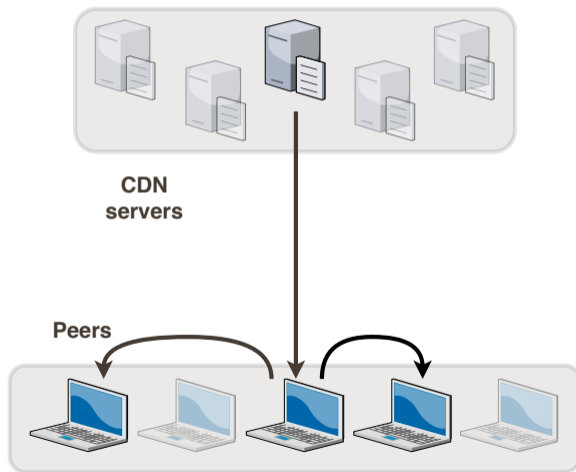


- ▶ High QoE
- ▶ Reliability
- ▶ Low scalability cost

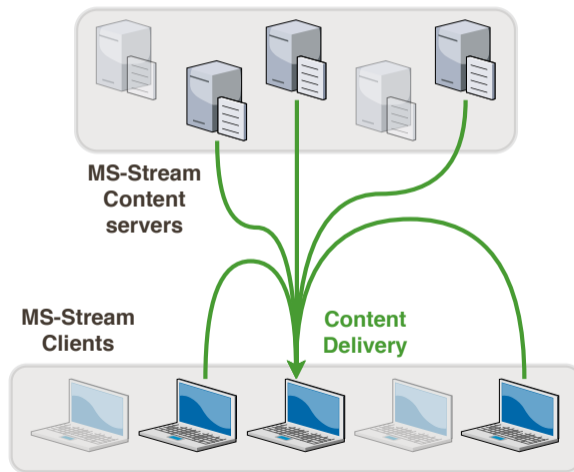
Low scalability cost: Edge-assisted CDN



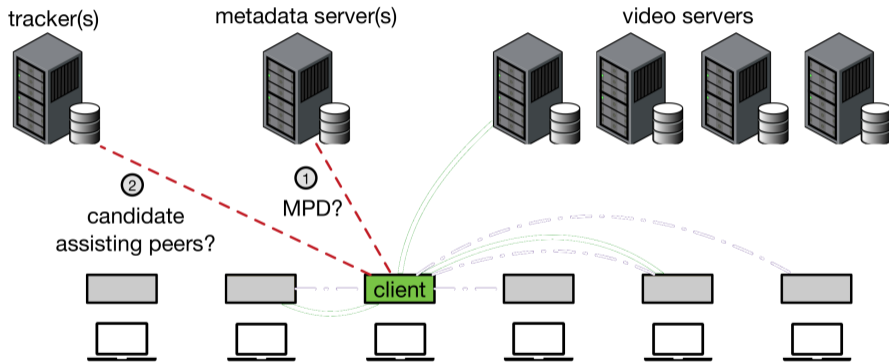
Low scalability cost: Edge-assisted CDN



Multi-source adaptive streaming with MS-STREAM



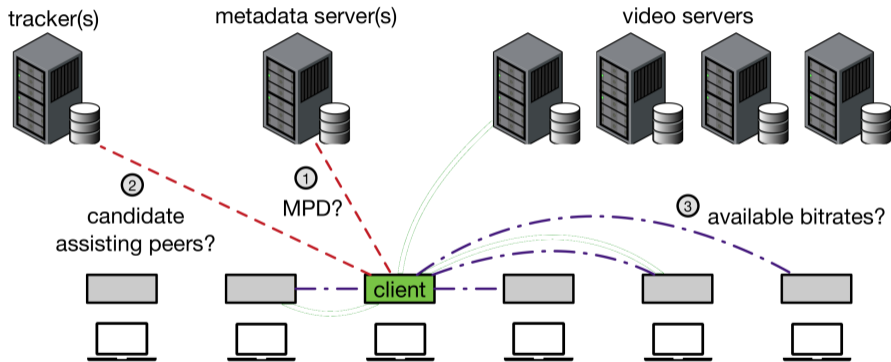
Multi-source adaptive streaming with MS-STREAM



selected assisting peer

- - - requests for metadata
- · · discovery of available bitrates
- requests for video sub-segments

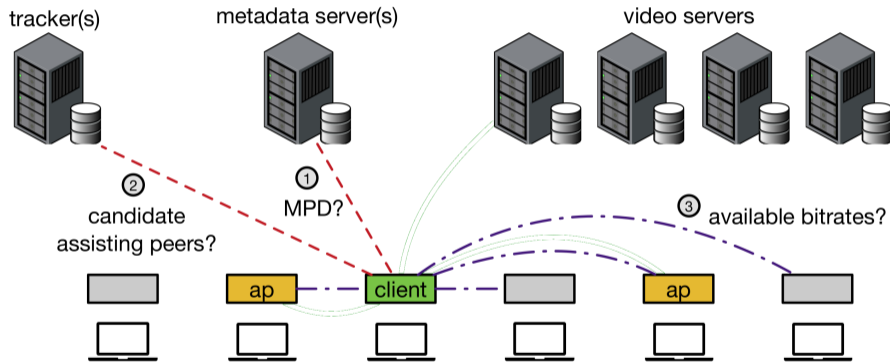
Multi-source adaptive streaming with MS-STREAM



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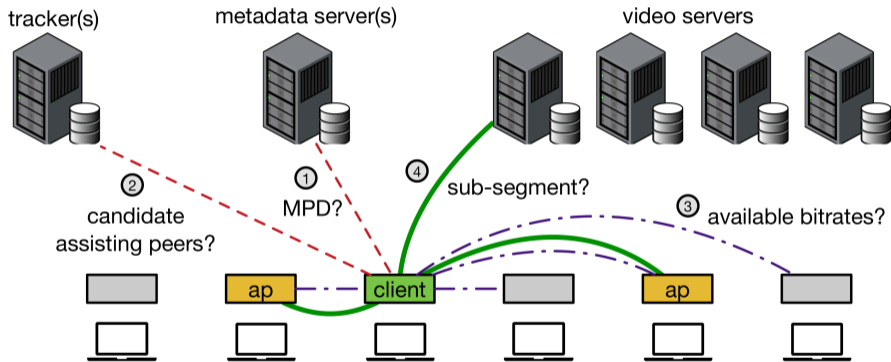
Multi-source adaptive streaming with MS-STREAM



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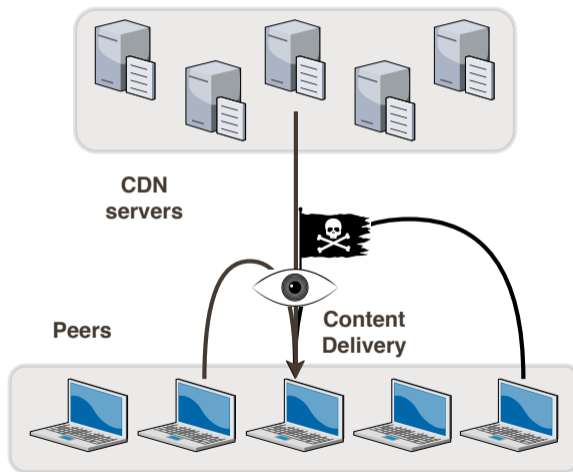
Multi-source adaptive streaming with MS-STREAM



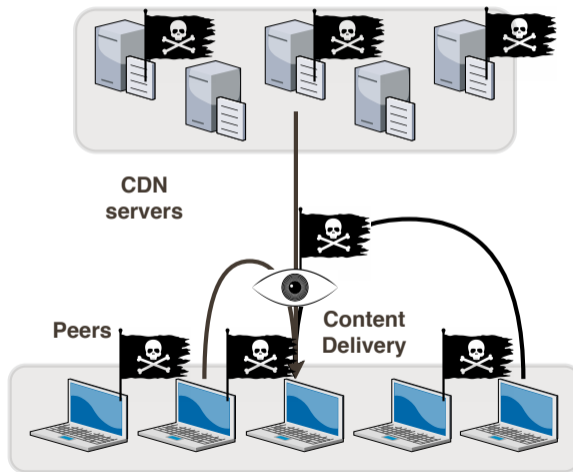
Edge-assisted CDN and privacy

People are mostly reluctant to seed content because of **privacy issues**.

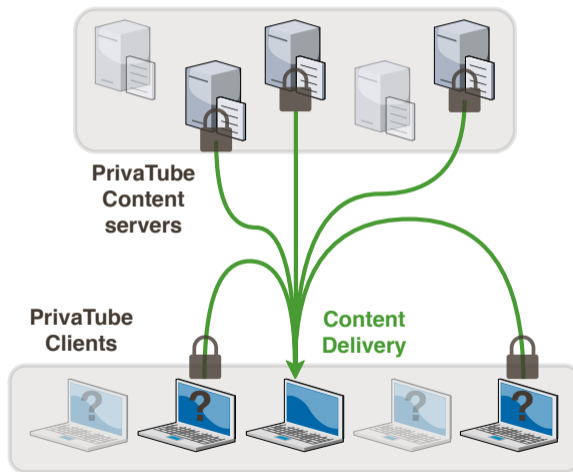
Privacy objective



Adversary model



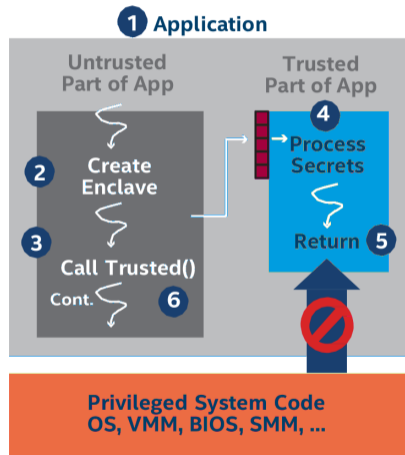
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PRIVATUBE HTTP proxies

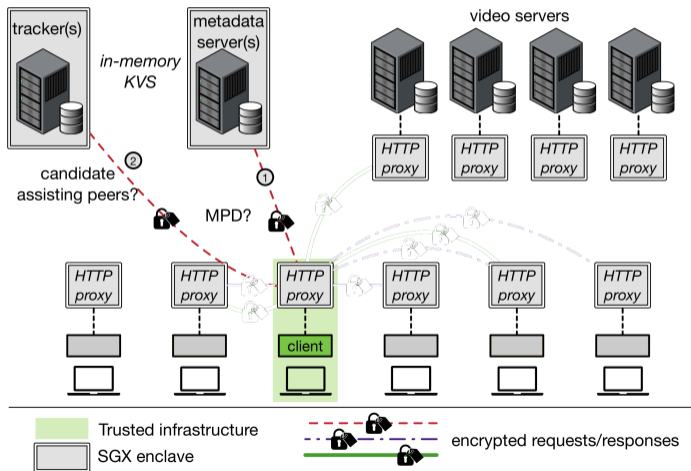
- ▶ Queries encryption
e.g. Game of Thrones
→ *R2F8MgbYgGhyb2*
- ▶ IP addresses encryption
e.g. Alice → *9jB4q*
e.g. Server1 → *7Tl13nV*
- ▶ Video stream encryption

SGX enclaves

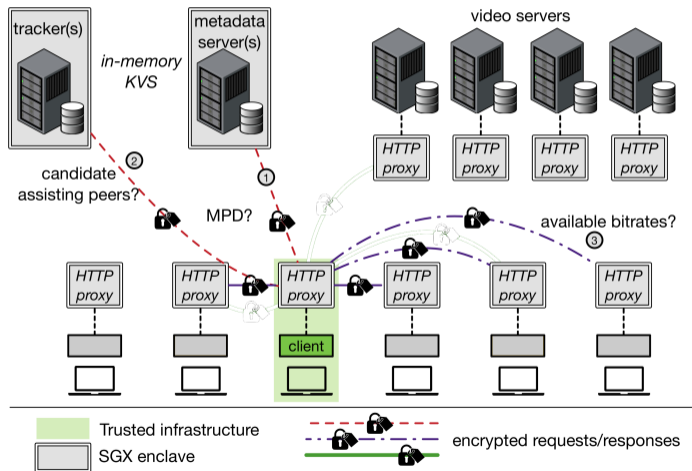


<https://software.intel.com> - Intel SGX Product brief

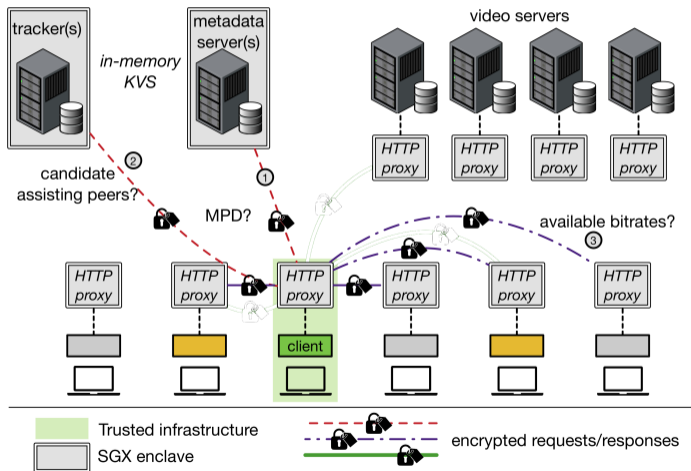
PRIVATUBE architecture



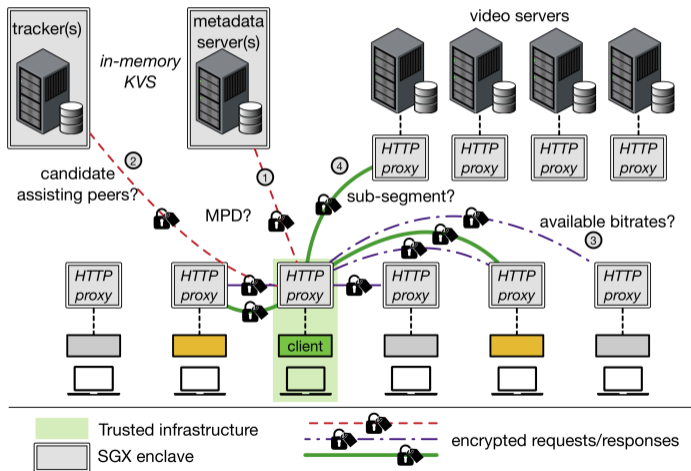
PRIVATUBE architecture



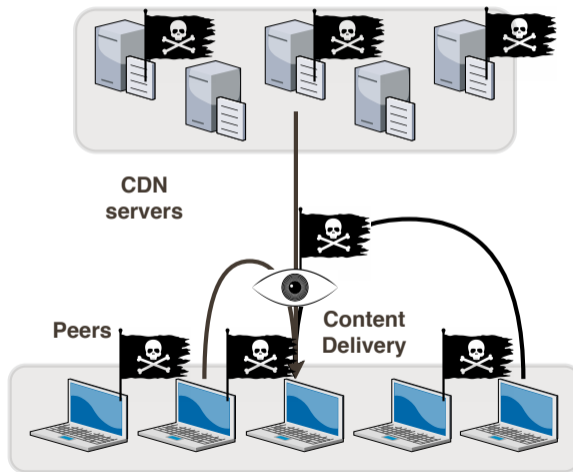
PRIVATUBE architecture



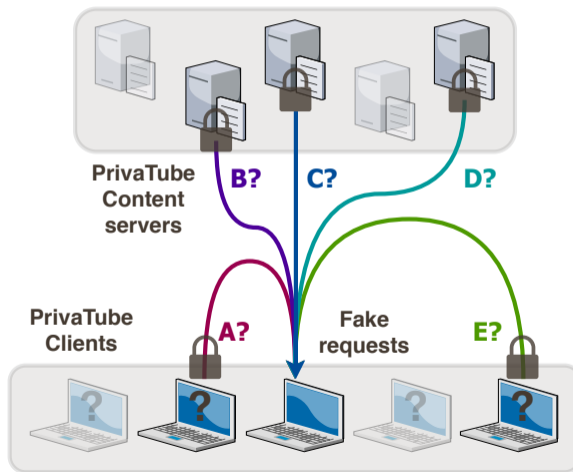
PRIVATUBE architecture



Adversary model



PRIVATUBE fake requests



PRIVATUBE fake requests

Enforce privacy (probabilistic δ -unlinkability)

- ▶ **popularity**-aware
fake requests policy

Fake requests according to contents popularity

- ▶ Content pre-fetching

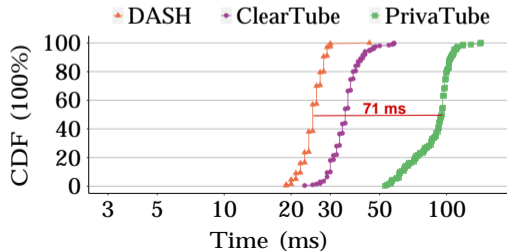
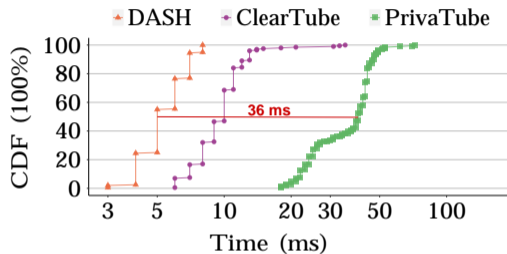
Streaming solutions

	Adaptive	Multi-source	Edge-assisted	Private
DASH	✓	×	×	×
ClearTube	✓	✓	✓	×
PRIVATUBE	✓	✓	✓	✓

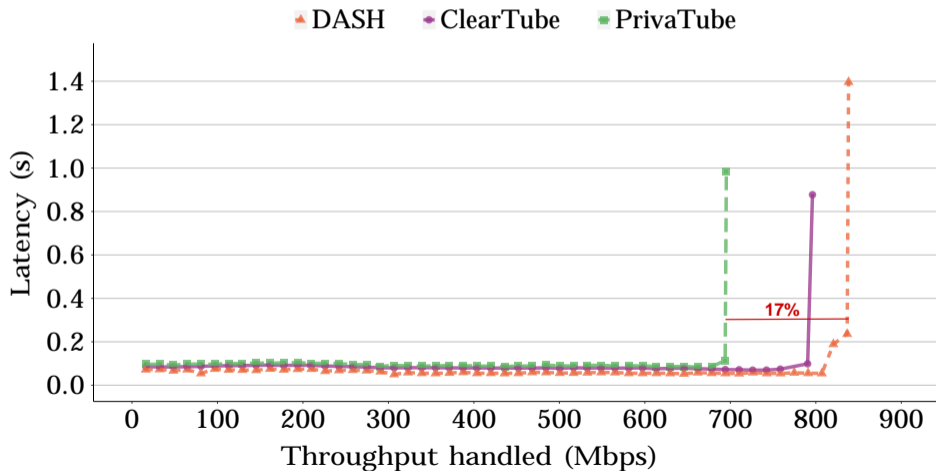
Micro-benchmarks setup



Download time, LD (top) and HD (bottom) segments



Throughput and latency



QoE evaluation setup

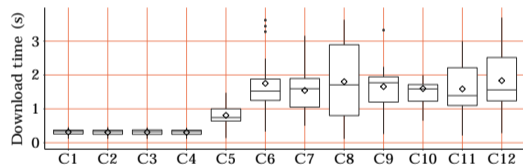
1. Low download time
2. High displayed bitrate

15 NUCs (computers):

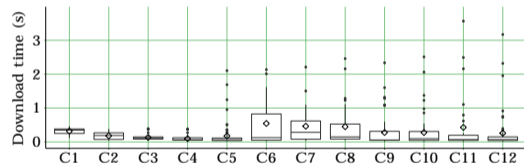
- ▶ 1 tracker server
- ▶ 1 metadata server
- ▶ 1 content server
- ▶ 12 consuming clients
C1, C2, C3, C4, C5-C12

QoE evaluation, download time

DASH

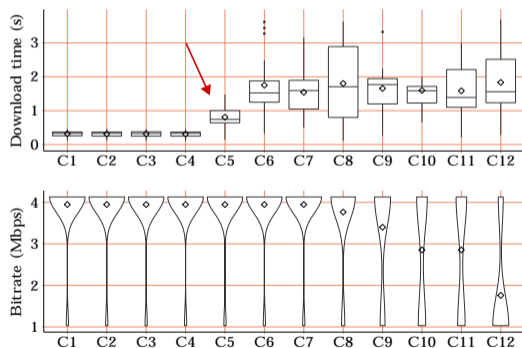


PRIVATUBE

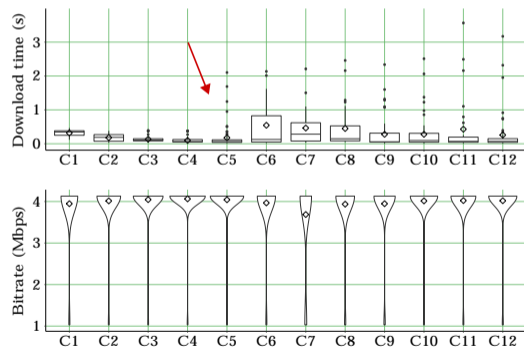


QoE evaluation, download time (top) and displayed bitrate (bottom)

DASH

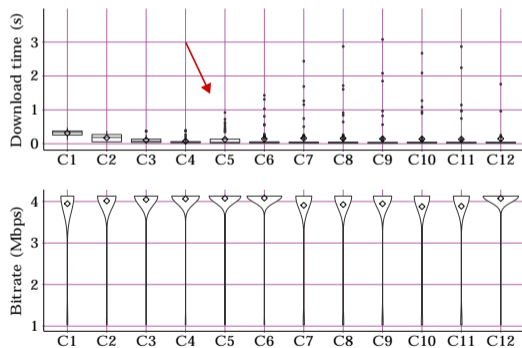


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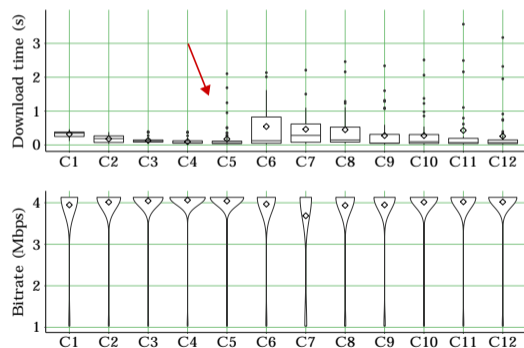


QoE evaluation, download time (top) and displayed bitrate (bottom)

ClearTube



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Privacy evaluation setup

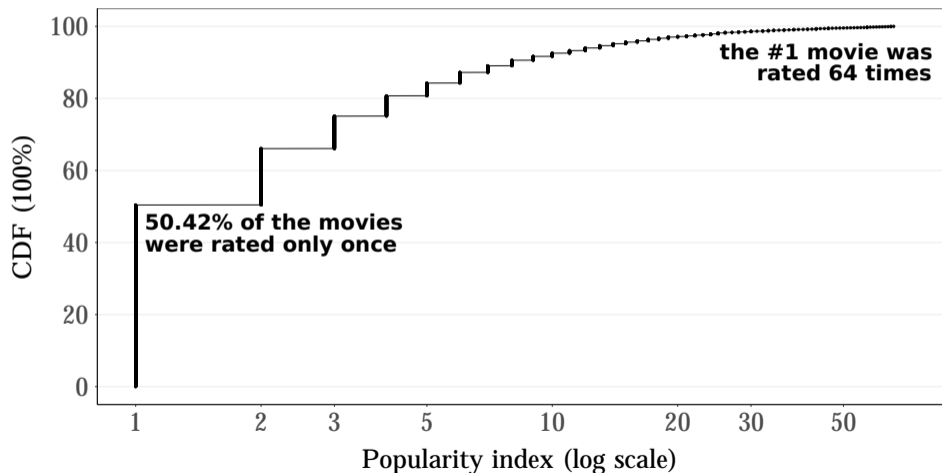
1. Privacy (δ -unlinkability)
2. Content pre-fetching

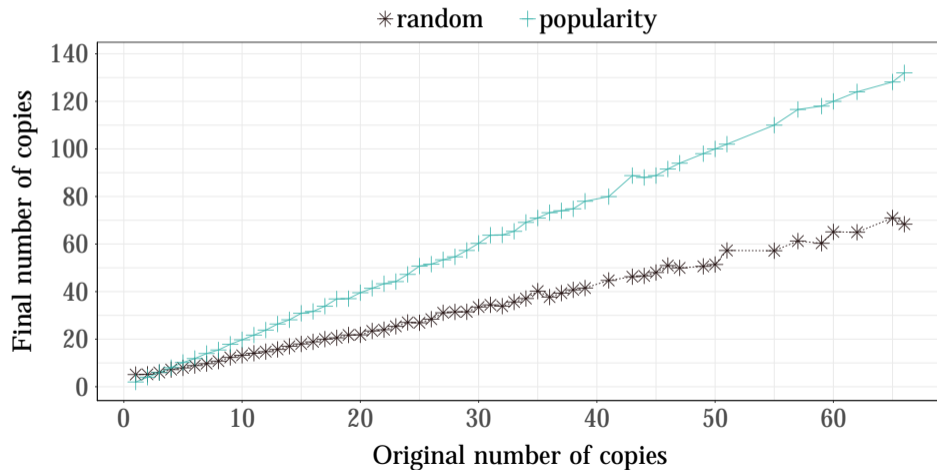
- ▶ **random**
- ▶ **popularity**-aware

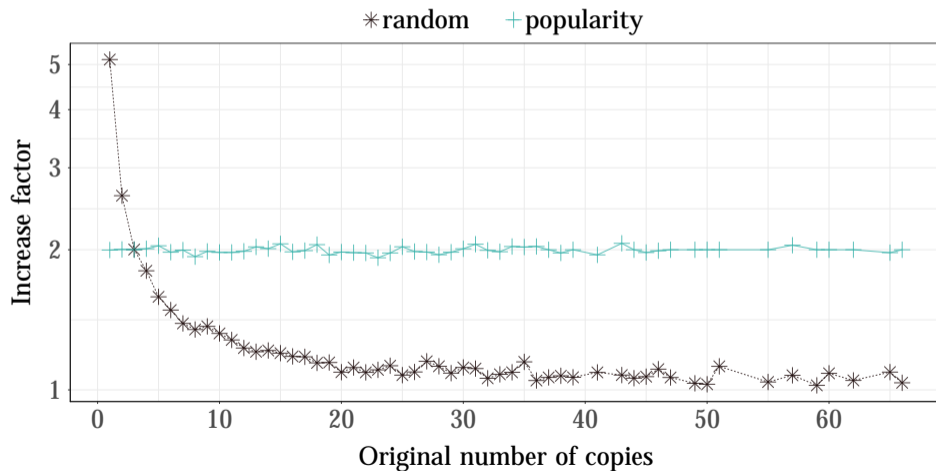
MovieLens 20M dataset, year 2014

39,177 ratings from **7,763** users for **4,283** movies

Distribution of movies popularities in MovieLens



Movies copies, $\delta = 50\%$ 

Movies copies increase factor, $\delta = 50\%$ 

Conclusion

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- ▶ High QoE
- ▶ Reliability
- ▶ Scalability

Multiple-source, edge-assisted, adaptive video streaming

- ▶ Privacy

HTTP proxies inside SGX performing encryption and fake requests

- ▶ Pre-fetching

Fake requests according to contents popularity

Plan

Video streaming

Context

Background

Problem statement

PRIVATUBE

Overview

Architecture

Fake requests

Evaluation

Micro-benchmarks

QoE evaluation

Privacy evaluation